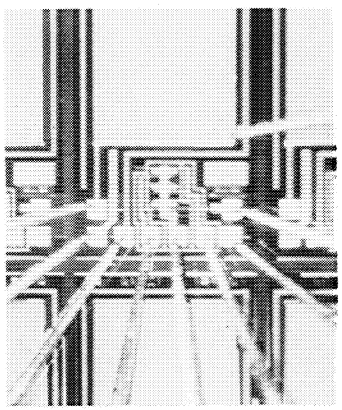
Cure Monitoring



Microdielectrometry is definitely not a household word and few can define it, but it is a technology of growing importance at a time of rapidly increasing use of composite materials in high performance military and commercial products. Composites, invariably lighter and usually stronger than the metals they replace, are sheets of woven fibers impregnated with a matrix of resin or other material. A vital step in their manufacture is the curing process, which is critical to the strength, quality and consistency of the product.

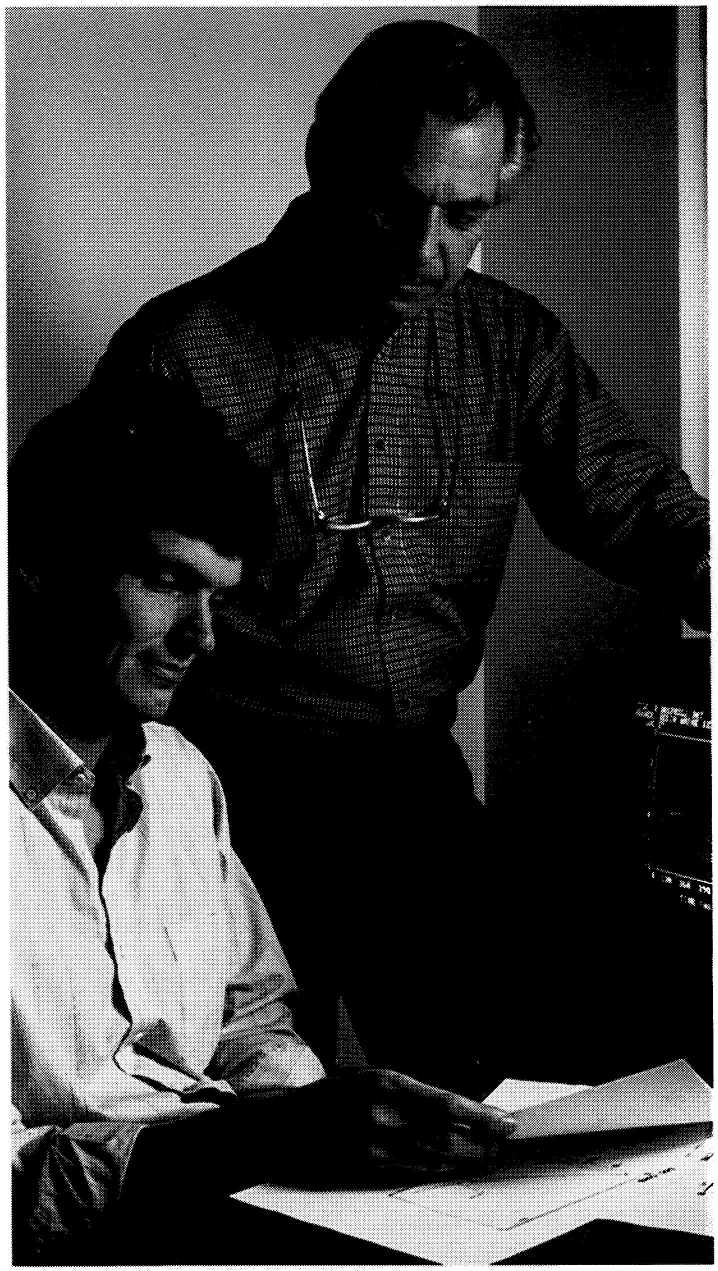
That's where microdielectrometry comes in. Its principal application is monitoring the chemical changes that take place when resins, adhesives and plastics are cured or processed, for example, measuring the behavior of the resins used to bind fiber reinforced composites for aircraft, spacecraft or jet engines—in other words, providing information that enables precise control of the curing process for optimum results.

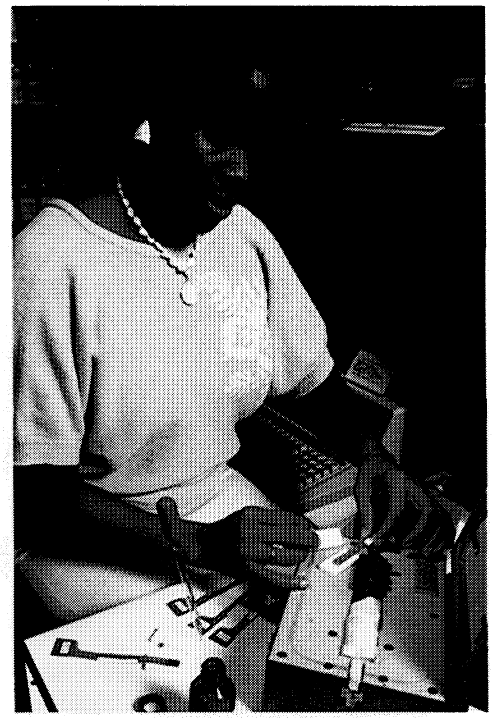
Micromet Instruments, Inc., Cambridge, Massachusetts, manufactures the Eumetric System II Microdielectrometer, key to which is a miniature electronic probe—a silicon microchip—that contains electrodes and circuitry for measuring the electrical properties of whatever material is placed in contact with the electrodes; the microchip, magnified 15 times, is shown at left. The rest of the system consists of additional sensors, electronic components, microcomputer modules and software.

In composite curing, usually carried out in autoclaves, large pressure vessels that can be heated to as much as 800 degrees Fahrenheit, the microdielectrometer is used to probe the resins as they cure in the autoclave. The sensors communicate data to the system's computer about the chemical changes occurring. At left below, Micromet's Dr. Huan Lee is preparing a test of a polymer resin, dipping a ribbon sensor in the resin; the large black box is the Eumetric System II Microdielectrometer. Above, Lee is using a microscope to position the silicon microchip on the ribbon and at center right engineers are studying the results of the test.

The instrument is also used in quality control laboratories to verify the properties of new batches of materials and in research laboratories to investigate the cure behavior of new materials. At far right, Dr. Brenda Holmes, research scientist at the Naval Research Laboratory in Washington, D.C., is using the microdielectrometer to study the cure characteristics of a polymer network.

The System II Microdielectrometer and the art of microdielectrometry trace their roots to NASA's Technology Utilization Program. Principal inventor of the technology is Stephen D. Senturia, a professor of electrical engineering at Massachusetts Institute of Technology (MIT). During the early 1970s, Senturia served as a consultant to a NASA technology utilization contractor seeking to develop urban applications for NASA technology, in particular a project involving development of an advanced home fire alarm. The consulting group found potential utility in research performed by Dr. Norman Byrd of McDonnell Douglas Corporation who, investigating safety devices for spacecraft, had been working on





polymeric thin films that would change their electrical properties when exposed to hazardous gases.

NASA funded two contracts to explore this potential, one with McDonnell Douglas for additional polymer research and another with MIT under which Senturia was to seek new methods of measuring electrical properties with an eye toward developing low-cost components of a home fire alarm. In the course of this contract, Senturia invented the "charge-flow transistor," a microchip for measuring the electrical properties of thin polymer films. A direct ancestor of the microdielectrometer, the first successful device was built at MIT in 1976.

The NASA contract failed to produce a commercial product but Senturia continued his work under sponsorship of the Office of Naval Research and the National Science Foundation; ultimately, with the aid of others at MIT, he developed the present microdielectrometer. In 1982, Senturia and four colleagues obtained a license from MIT for the technology and founded Micromet Instruments. The technology is finding wide acceptance among government agencies, aerospace firms, chemical and electronic companies. ▲